Comparison of digital subtraction angiography with 3D high-resolution MR vessel wall imaging for the evaluation of basilar artery atherosclerotic stenosis and plaque distribution

Aofei Liu[1], Xihai Zhao[2], Huijun Chen[2], Zhensen Chen[2], William Kerwin[3], Chun Yuan[2,3], Bin Du[1], and Wei-Jian Jiang[1]

[1]*New Era Stroke Care and Research Institute, The Second Artillery General Hospital PLA, Beijing, China,* [2]*Center for Biomedical Imaging Research & Department of Biomedical Engineering, Tsinghua University, Beijing, China,* [3]*Department of Radiology, University of Washington, Seattle, WA, United States*

Introduction: Intracranial atherosclerotic disease is increasingly recognized as an important cause of ischemic stroke, particularly in Asian population [1]. Currently, evaluation of atherosclerotic disease severity mainly relies on measuring luminal stenosis using angiographic approaches in clinical practice. However, measure of stenosis has been demonstrated to underestimate severity of atherosclerosis due to positive remodeling effect [2,3]. In addition, assessment of cross-sectional plaque distribution in intracranial arteries, such as middle cerebral artery and basilar artery, might be crucial for prevention of periprocedural ischemic events during stenting. This is because the perforating arteries arise from the particular side of arterial wall. Digital subtraction angiography (DSA) has been widely used to determine luminal stenosis as well as lesion distribution for cerebrovascular diseases. A number of studies proved that MR vessel wall imaging enables characterization of cerebrovascular plaque burden, distribution and vulnerability by viewing plaque directly [4,5]. This study sought to compare DSA and MR vessel wall imaging in evaluating the degree of stenosis and plaque distribution in BA.

Methods: Thirty three symptomatic patients (23 males, mean age 58.9 years) with BA plaque indicated by MRI were included. The patients underwent DSA and MRI examinations. DSA imaging was performed at Siemens robotic surgical C-Arm system Artis zeego via a transfemoral approach under monitored sedation or general anesthesia. Images were acquired with a matrix size of 1024×1024, FOV of 22cm, pixel size of 0.21×0.21 at 5 ml/s with standard anteroposterior, oblique and lateral views, as well as dedicated magnified and focused views. Intracranial MR angiography and 3D high-resolution vessel wall imaging were performed at a 3.0T MR scanner (Achieva TX, Philips, Best, The Netherlands) with a custom-designed 36-channel neurovascular coil. The MR imaging parameters were as follows: (1) 3D TOF-MRA: FFE, TR/TE 25/3ms, FOV 200×200×84mm^3, matrix size 400×400×60. (2) 3D VISTA-PDW [6]: TSE, TR/TE 2000/32ms, FOV 160×160×45mm^3, matrix size 320×320×45. ***MR image processing*** [7]***:*** A semi-automatic analysis tool was developed to generate cross-sectional vessel wall images that are perpendicular to BA centerline using TOF-MRA and VISTA images. BA in the cross-sectional image was divided into 4 quadrants, and wall area and lumen area in each quadrant and wall thickness (WT) in 120 equiangular radial directions were calculated. Then normal BA WT was obtained from those images that were free of plaque. A quadrant is considered affected by plaque when its maximum WT is larger than the normal BA WT plus 2 times of standard deviation. The stenosis indexes of the cross-sectional slices with plaque were calculated. ***DSA image interpretation:*** The DSA images were reviewed by two experienced neuroradiologists blinded to MR images. Presence of plaque in the left and/or right side can be identified using focused anteroposterior view; while presence of plaque in anterior and/or posterior side can be identified using focused lateral view. Degree of stenosis was defined as $[1-(D_{stenosis}/D_{reference})]\times100$ according to the WASID methodology [8].***Statistical analysis:*** Pearson correlation analysis was used to determine the relationship of stenosis measurement between DSA and MRI. The luminal stenosis was rated into 3 degrees: normal (0%), 1%-50% and >50%. Prevalence of plaque affecting vessel wall in different quadrants were calculated in patients with plaque that was presented on both DSA and MRI.

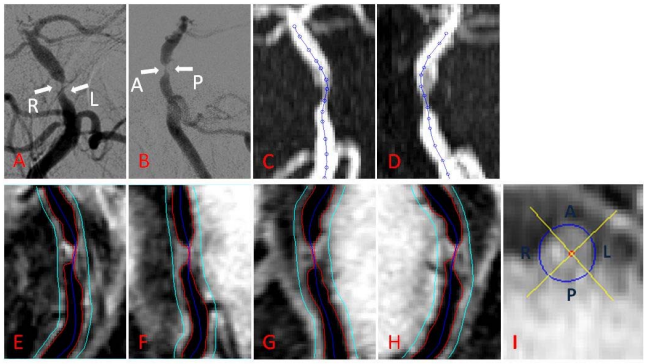

Fig.1: A typical subject with severe BA stenosis. A, B: DSA anteroposterior and lateral views; C, D: MRA coronal and sagittal views. The dark blue line represents BA centerline; E~H: Curviplanar reformatted images along the centerline from 4 viewing angles. The red and green lines represent lumen and wall boundary respectively; I: Cross-sectional image with maximum lumen narrowing. Both DSA and MR vessel images show the annular plaque.

Results: Of the 33 subjects, 2 were excluded due to poor DSA image quality. **Fig.2** shows a typical subject with severe BA stenosis. The degree of stenosis measured by DSA and MRI was 32.9% ± 39.2% and 42.9% ± 35.0%, respectively. Excellent agreement was found between DSA and MRI in stenosis measurement (r=0.898, P<0.001) (**Fig.2**). We found 10 (32%) subjects appeared normal lumen size on DSA images but various stenosis on MR vessel wall images (**Table.1**). The incidence of plaque affecting each quadrant determined by MRI was greater than that determined by DSA (**Fig.3**).

Table.1: Summary of degree of stenosis

HR-MRI	DSA			
	Normal(0)	1%-50%	>50%	Total
Normal	5	0	0	5
<50%	9	3	0	12
50-99%	1	3	10	14
Total	15	6	10	31

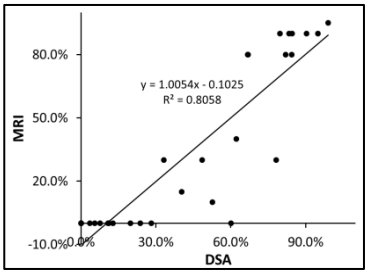

Fig.2: Regression plot

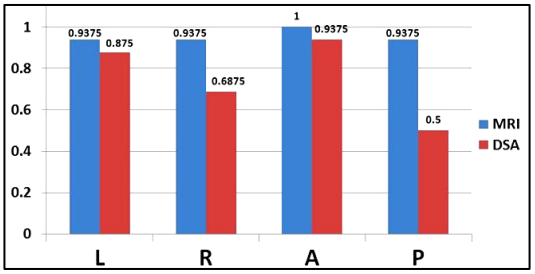

Fig.3: Quadrants affected by plaque

Discussion and Conclusions: In measurement of stenosis, DSA and MR vessel wall imaging showed excellent agreement. However, DSA underestimated degree of luminal stenosis, which may be due to its limited views for characterizing eccentrically stenotic lesion. In this study, the incidence of plaque affecting each quadrant on MRI is greater than that of DSA, which suggests that MR vessel wall imaging might be a better imaging modality to evaluate the lesion distribution at BA.

References:

1. Wong KS, et al. Neurology.1998;50:812-813; 2. Chen JW, et al. Neuroimaging Clin N Am.2005;15:609-621; 3. Yuan C, et al. Neuroimaging Clin N Am.2002;12:391– 401; 4. Wei-Hai Xu, et al. Stroke.2011;42:2957-2959; 5. Cai JM, et al. Circulation. 2002;106(11):1368-73 6. Qiao Y, et al. JMRI. 2011;34:22-30; 7. Zhensen Chen, et al. ISMRM 2013 abstract 4641; 8. Samuels OB, et al. AJNR. 2000;21:643-646.